system design & management

Best Practices for Water Use at Thermoelectric Facilities

MITsdm

- Donny Holaschutz, SDM'10 & inodú cofounder
- Jorge Moreno, SDM'11 & inodú cofounder
- Carolina Gómez, Sustainable Development Division
  Ministry of Energy, Chile

May 8, 2017

From left: Jorge Moreno, SDM ’11; Donny Holaschutz, SDM ’10; and Carolina Gomez

Jorge Moreno and Donny Holaschutz, Cofounders, inodú; SDM Alumni

Carolina Gomez, Sustainable Development Division, Ministry of Energy, Chile

Agenda

- The social challenges created by water use at thermoelectric facilities
- Summary of associated policy and regulatory initiatives in Chile
  1. The process
  2. The results
- Water use in Thermoelectric Facilities in Chile
- Key Impacts Addressed by Guide
- Alignment between International Best Practices and Chilean Regulation
- Interesting Analysis and Insights Gathered During Guide Definition Process
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Why was the Ministry of Energy interested in studying good practices for water use at thermoelectric plants?

The Challenge: Environmental impact on marine environment from the lack of technology which minimizes adverse environmental impacts and the operation of cooling water systems in thermoelectric power plants

Presentarán una denuncia por hallazgo de langostinos en pozos de termoeléctrica Santa María de Colbún

04.04.2013 La acusación será interpuesta por las algueras y orilleras de Coronel, en conjunto con el senador Alejandro Navarro, por las toneladas de estas especies marinas que aparecieron en los charcos de la empresa ubicada en el sector Playa Negra de la comuna minera.

MITsdm

The Challenge: Environmental impact on marine environment from the lack of technology which minimizes adverse environmental impacts and the operation of cooling water systems in thermoelectric power plants

Cientos de jaibas aparecieron muertas en la caleta Lo Rojas de Coronel

ARTURO PARDOW R.

16.03.2013 Según los vecinos, la mortandad se debería a los residuos vertidos por las termoeléctricas Bocamina I y II, Santa María y Colbún.

n una denuncia por hallazgo de s en pozos de termoeléctrica a de Colbún

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MITsdm

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Bocamina I y II, Santa María y Colbún.

Termoeléctrica Bocamina paralizada totalmente por masiva succión de recursos marinos

Posted on 30 enero, 2014 by El Ojo Ciudadano Chile

Anticipándose a la clausura de Bocamina I que pidió al superintendente de Medio Ambiente la fiscal a cargo del proceso sancionatorio contra la termoeléctrica, Endesa informó que procedió a suspender su operación. La medida, con la paralización de Bocamina II desde el mes pasado, deja a la termoeléctrica en Coronel con un cese de operación total.

MITsdm

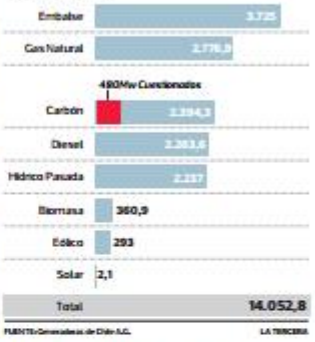
The Challenge: Environmental impact on marine environment from the lack of technology which minimizes adverse environmental impacts and the operation of cooling water systems in thermoelectric power plants

Negocios

▸▸ Máximo tribunal acogió recurso presentado por pescadores y algueros de caleta Lo Rojas. FOTO: CAMILA LABBÉ

CAPACIDAD INSTALADA EN EL SIC

Por tecnología En Mw



FUENTE: Generadoras de Chile A.G. LA TERCERA

Suprema deja en manos de la SMA paralización de central Bocamina I

- Fallo ordenó que SMA revise medidas de cumplimiento ambiental de central termoeléctrica.
- Salida prolongada de 480 megawatts afectaría costos marginales en el SIC, aunque no habría problemas de suministro.

A. Astudillo/N. Keller

En fallo dividido -con un voto de minoría- la Tercera Sala de la Corte Suprema dejó en manos de la Superintendencia de Medio Ambiente (SMA) la decisión de paralizar las operaciones de Bocamina I y II, centrales a carbón de Endesa, que aportan el 20% de la generación a carbón del mayor sistema eléctrico del país.

"La compañía recurrida -Endesa- deberá realizar las operaciones de la planta de generación termoeléctrica Bocamina I y II sólo si su funcionamiento no importa en la succión de las aguas amenazas ni daño a especies y recursos hidrobiológicos y cumple, estrictamente, con la correspondiente Resolución de Calificación Ambiental, debiendo en consecuencia la autoridad ambiental fiscalizar ese funcionamiento de manera periódica para así evitar el ingreso de biota en la bocatoma de agua de mar; y, en caso contrario, adoptar todas las medidas que las circunstancias determinen, entre ellas la paralización del funcionamiento de la central hasta que se subsane su incorrecta operación", señala el fallo.

De esta forma, la Suprema acogió el recurso de protección presentado por pescadores y recolectores de algas de la caleta Lo Rojas, en Coronel. Con anterioridad, el recurso había sido rechazado por la Corte de Apelaciones.

La decisión tuvo el voto a favor de los ministros Sergio Muñoz, Héctor Carreño, Lamberto Cisternas y Gloria Ana Chevesich. En contra votó el abogado integrante Alfredo Prieto.

En una declaración pública, Endesa aseguró que el fallo no obliga a la firma a paralizar Bocamina I (128 Mw).

El ministro y presidente de la Corte Suprema, Sergio Muñoz, señaló a la salida de una reunión de más de dos horas que mantuvo en La Moneda con el Primer Mandatario, Sebastián Piñera, que será la autoridad ambiental la que certifique si la unidad puede seguir operando. "En los temas ambientales y de inversión en energía, hemos dado muestras, precisamente en este caso de Bocamina, que estamos confiando en la autoridad administrativa para que ella ejerza sus funciones. Hemos encomendado a la autoridad administrativa que inspeccione y supervigile los proyectos. Creemos que hay una mayor responsabilidad de la autoridad administrativa, que ella tiene que desarrollar sus labores. Le estamos pidiendo que ejerza sus funciones", dijo.

Por su parte, el ministro de Energía, Jorge Bunster dijo que la decisión del tribunal debe acatarse, pero manifestó que esperaba que el tema se resolviera en un plazo breve.

"Me resisto a pensar que esto es una situación permanente, que el país va a tener que prescindir de esa capacidad. Creo que hay que buscar los mecanismos para subsanar las debilidades que se estén observando. Es generación importante para mantener los costos de energía bajos", dijo Bunster.

Sebastián Bernstein, de la consultora Synex, señaló que la falta de esta capacidad en el sistema, por un tiempo prolongado, impactará al alza en el costo marginal.

"Extremadamente negativo, no conozco los fundamentos del fallo, sobre todo el caso de Bocamina I, que acaba de salir. Pero la paralización de casi 500 MW en las condiciones actuales es muy grave para el país, no cabe duda", sostuvo.●

CENTRAL

128

megawatts de potencia instalada tiene Bocamina I. La unidad está en operación desde la década de 1970.

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1. The process: The Energy Agenda established in 2014

- Pillar N°1: New role of the State:
  - "We will support the development of specific regulations and instruments for the sector, in order to improve the environmental performance of energy projects."
  - "One of the initiatives in this line is to develop studies which regulate withdrawal and discharge of the cooling water of thermoelectric plants."

1. The process: ENERGY 2050 – Chile's Energy Policy

VISION AND PILLARS OF THE POLICY

RELIABILITY INCLUSIVENESS COMPETIVENESS SUSTAINABILITY

PILLAR 1
QUALITY AND SECURITY OF SUPPLY

PILLAR 2
ENERGY AS A DRIVING FORCE FOR DEVELOPMENT

PILLAR 3
ENVIRONMENTALLY-FRIENDLY ENERGY

PILLAR 4
ENERGY EFFICIENCY AND ENERGY EDUCATION

1. The process: Environmentally friendly energy (Pillar N° 3)

"Energy infrastructure which generates low environmental impact. Impacts should be first avoided, then mitigated and finally compensated, considering energy development and its implications in air, land, marine and inland water ecosystems."

1. The process:

First Study was developed in year 2014

inodú

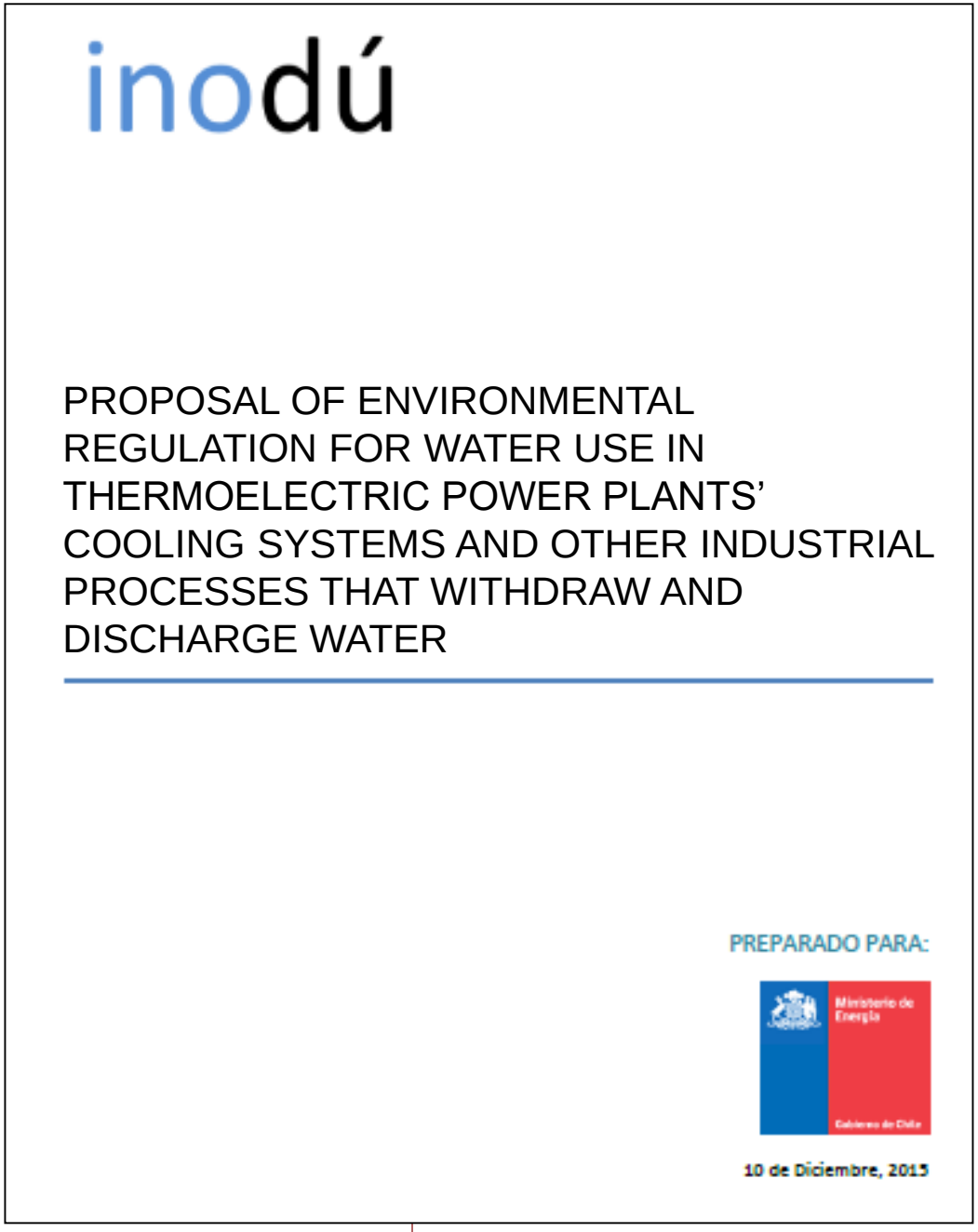
TECHNICAL, ECONOMIC, REGULATORY AND ENVIRONMENTAL ANALYSIS OF THERMOELECTRIC POWER PLANT TECHNOLOGIES AND THEIR COOLING SYSTEMS

REPORTE PREPARADO PARA:

15 de Diciembre, 2014

1. The process:

Second Study was developed in year 2015



Assessing Regulatory, Environmental, Economic, and Technical Components of Sustainable Energy and Water Use in Thermoelectric Facilities in Chile

Editor's note: The following is a summary of a study performed for the Chilean Energy Ministry with the support of the Ministry of the Environment. The authors would like to thank the Chilean Energy Ministry and Ministry of the Environment for supporting this project.

The challenge: Water use at thermoelectric facilities presents a complex systems problem for several reasons:

- To operate safely and efficiently, the facilities need large amounts of water, yet water supplies are limited;
- The social and environmental impacts of water use are becoming increasingly significant worldwide; and
- A complex set of relationships exists among the overall environmental, economic, and social impacts of water use; how water is withdrawn from its source; how it is used at facilities; and how it is returned to the environment.

The most significant water use at a thermoelectric facility is associated with the cooling process, which in turn is tightly coupled to the overall performance and reliability of the plant. An adequate amount of water for the plant's cooling system leads to a more energy-efficient thermoelectric facility—one that produces less atmospheric emissions per unit of electricity generated. This relationship creates an important tension in the design or upgrade of a plant's cooling system between water use and performance.

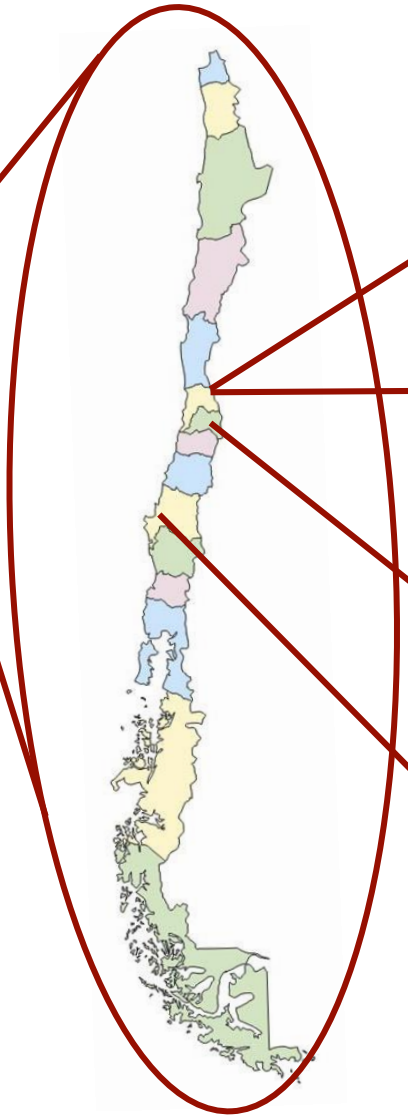
Any cooling system design must consider a variety of factors, including:

- local environmental conditions and geography, including access to and availability of water;
- the ecosystems of the source body of water;
- local social context; and
- how specific system byproducts—such as water flow at the intake and the temperature of the water effluent—might stress the source body of water.

Inodú worked with the Chilean Energy Ministry and the Ministry of the Environment to identify and address some of the challenges posed by water use at thermoelectric facilities in Chile by conducting a preliminary assessment of the current regulatory, environmental, economic, and technical situation. This assessment helped address the following goals presented in the Chilean Energy Ministry's Energy Agenda:

- supporting the sustainable development of thermoelectric generation projects;

1. The process:



Workshops and other activities

1. Workshop in Valparaíso and a visit to a power plant, October 2015.

2. Technical meeting in Valparaiso, November 2015 with General Direction of the Maritime Territory and Merchant Marine, Undersecretariat of Fisheries and Aquaculture, Ministry of the Environment and Ministry of Energy.

3.Workshop with Mexican experts in Santiago, November 2015.

4. Workshop in Concepcion, November 2015

1. The process: Stakeholders

Government Services:

- Ministry of the Environment
- Undersecretariat of Fisheries and Aquaculture
- Ministry of Economy
- Ministry of Public Works
- General Direction of the Maritime Territory and Merchant Marine
- Superintendence of the Environment

1. The process: Stakeholders

Private Sector:

- Association of Generators of Chile
- Colbun
- Enel
- Aes Gener
- Engie

1. The process: Stakeholders

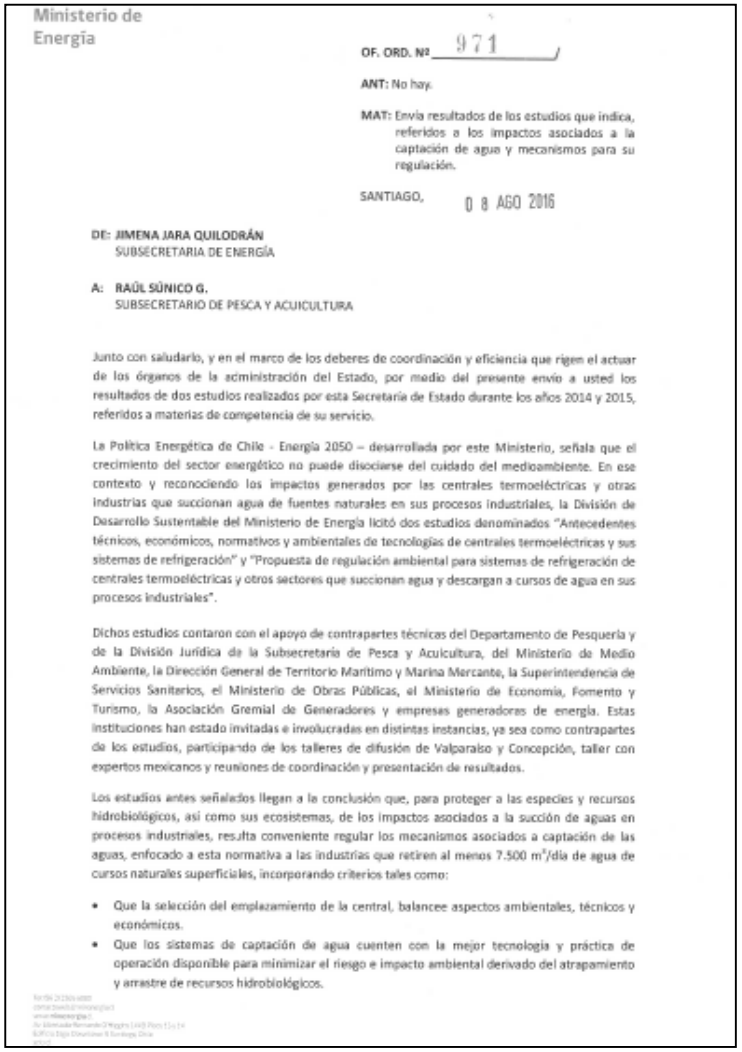
Ministry of Energy:

Sustainable Development Division
Legal Division
Project Management Unit
Security and Energy Markets Division
Energy Regional Ministerial Secretariat of Antofagasta, Atacama, Valparaíso and Bio Bio

2. The results: Guide with good practices for the use of cooling water at thermoelectric power plants

Indicative guide aimed at reducing impacts on marine biota by the withdraw and discharge of water from thermoelectric plants

2. The results: Proposal of a compulsory regulation



Ministerio de Energía

OF. ORD. Nº 971

ANT: No hay.

MAT: Envía resultados de los estudios que indica, referidos a los impactos asociados a la captación de agua y mecanismos para su regulación.

SANTIAGO, 08 AGO 2016

DE: JIMENA JARA QUILODRÁN
SUBSECRETARIA DE ENERGÍA

A: RAÚL SÚNICO G.
SUBSECRETARIO DE PESCA Y ACUICULTURA

Junto con saludarlo, y en el marco de los deberes de coordinación y eficiencia que rigen el actuar de los órganos de la administración del Estado, por medio del presente envío a usted los resultados de dos estudios realizados por esta Secretaría de Estado durante los años 2014 y 2015, referidos a materias de competencia de su servicio.

La Política Energética de Chile - Energía 2050 – desarrollada por este Ministerio, señala que el crecimiento del sector energético no puede disociarse del cuidado del medioambiente. En ese contexto y reconociendo los impactos generados por las centrales termoeléctricas y otras industrias que succionan agua de fuentes naturales en sus procesos industriales, la División de Desarrollo Sustentable del Ministerio de Energía licitó dos estudios denominados "Antecedentes técnicos, económicos, normativos y ambientales de tecnologías de centrales termoeléctricas y sus sistemas de refrigeración" y "Propuesta de regulación ambiental para sistemas de refrigeración de centrales termoeléctricas y otros sectores que succionan agua y descargan a cursos de agua en sus procesos industriales".

Dichos estudios contaron con el apoyo de contrapartes técnicas del Departamento de Pesquería y de la División Jurídica de la Subsecretaría de Pesca y Acuicultura, del Ministerio de Medio Ambiente, la Dirección General de Territorio Marítimo y Marina Mercante, la Superintendencia de Servicios Sanitarios, el Ministerio de Obras Públicas, el Ministerio de Economía, Fomento y Turismo, la Asociación Gremial de Generadores y empresas generadoras de energía. Estas instituciones han estado invitadas e involucradas en distintas instancias, ya sea como contrapartes de los estudios, participando de los talleres de difusión de Valparaíso y Concepción, taller con expertos mexicanos y reuniones de coordinación y presentación de resultados.

Los estudios antes señalados llegan a la conclusión que, para proteger a las especies y recursos hidrobiológicos, así como sus ecosistemas, de los impactos asociados a la succión de aguas en procesos industriales, resulta conveniente regular los mecanismos asociados a captación de las aguas, enfocado a esta normativa a las industrias que retiren al menos 7.500 m^3/día de agua de cursos naturales superficiales, incorporando criterios tales como:

- Que la selección del emplazamiento de la central, balancee aspectos ambientales, técnicos y económicos.
- Que los sistemas de captación de agua cuenten con la mejor tecnología y práctica de operación disponible para minimizar el riesgo e impacto ambiental derivado del atrapamiento y arrastre de recursos hidrobiológicos.

Ministerio del Medio Ambiente
Gobierno de Chile

Ministry of the Environment can't regulate, because they regulate pollutants ✗

Subsecretaría de Pesca y Acuicultura
Gobierno de Chile

Undersecretariat of Fisheries and Aquaculture can regulate through Fisheries Law ✓

One of the objectives of this Law is:

"The conservation and sustainable use of hydrobiological resources through the application of the precautionary approach, an ecosystem approach to fisheries regulation and the safeguarding of marine ecosystems where such resources exist."

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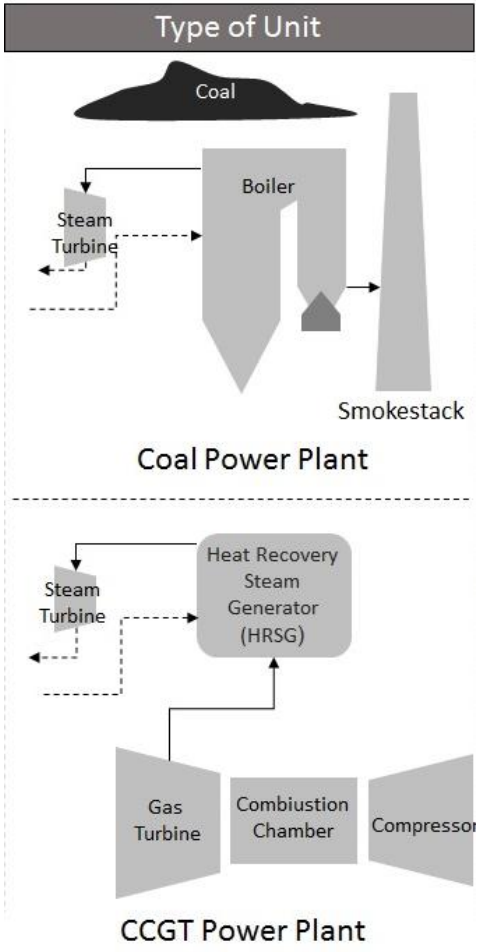
Water Use in Thermoelectric Facilities



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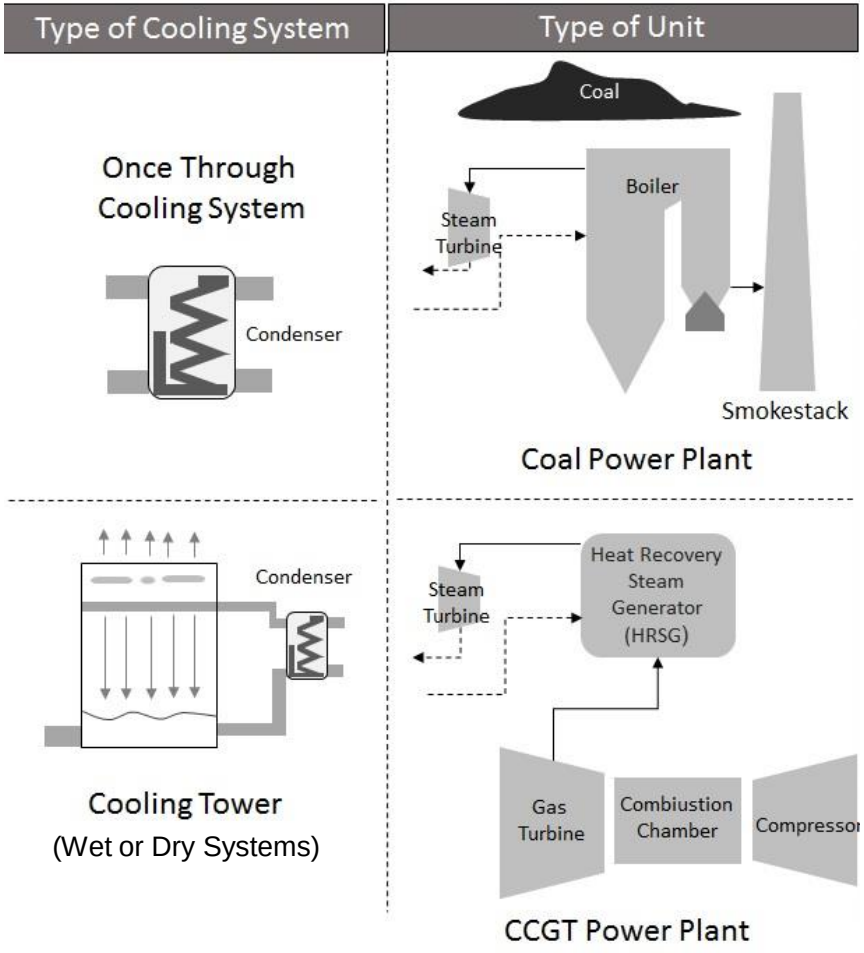

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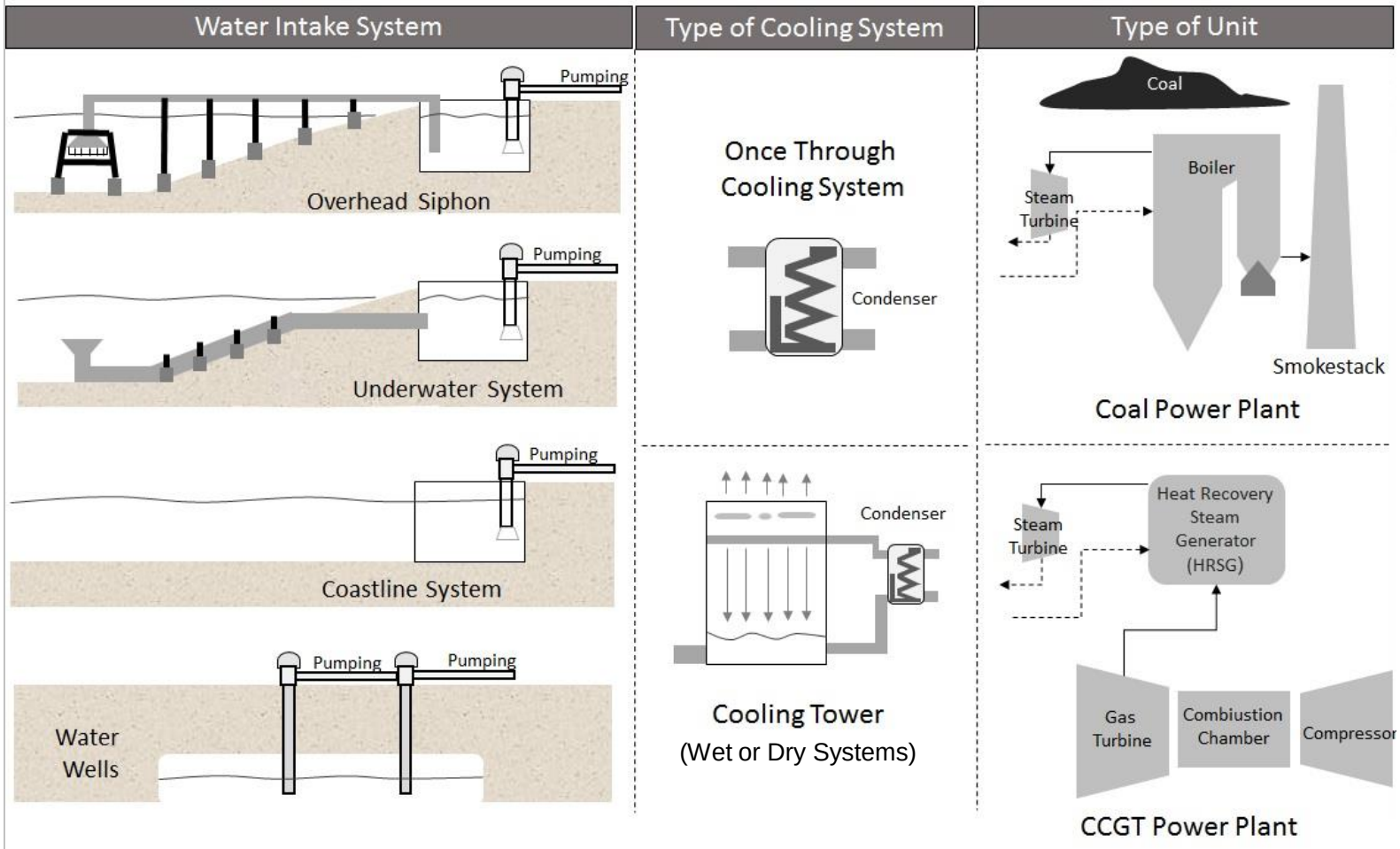
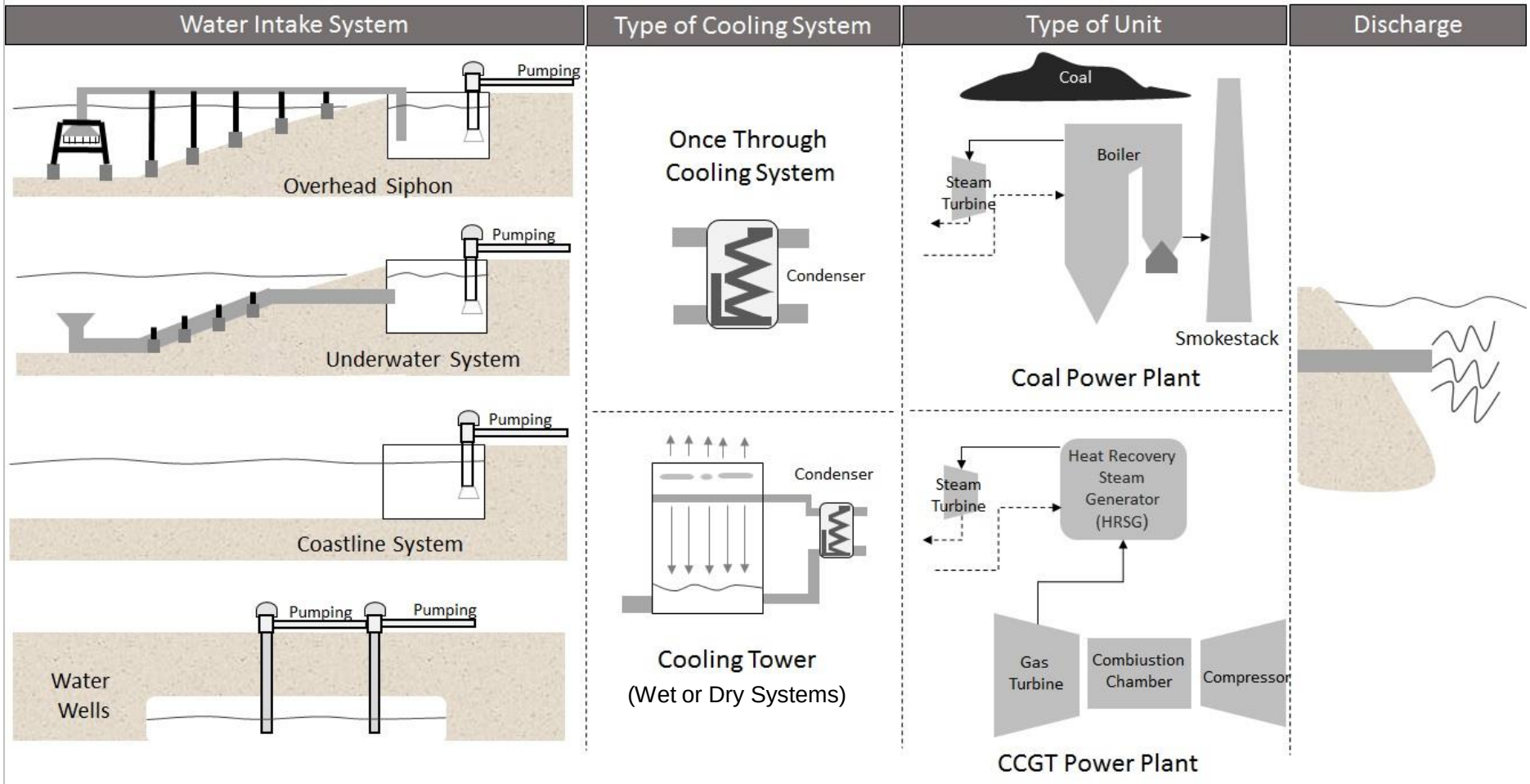


Water Use in Thermoelectric Facilities



System Design & Operational tradeoffs: Complex interactions driven by techno-economic, environemental, policy (environmental & social), and social (facts & perceptions) requirements

Water Use

Safety

Maintenability

Reparability

Modularity

Environmental Impact (Air Pollutants)

Cost

Water Withdrawal

Sustainability

Water Consumption

Coastal Planning & Land Use

Efficiency of the Thermoelectic Power Plant

Environmental Impact (Impingement, Entrainment, Discharges)

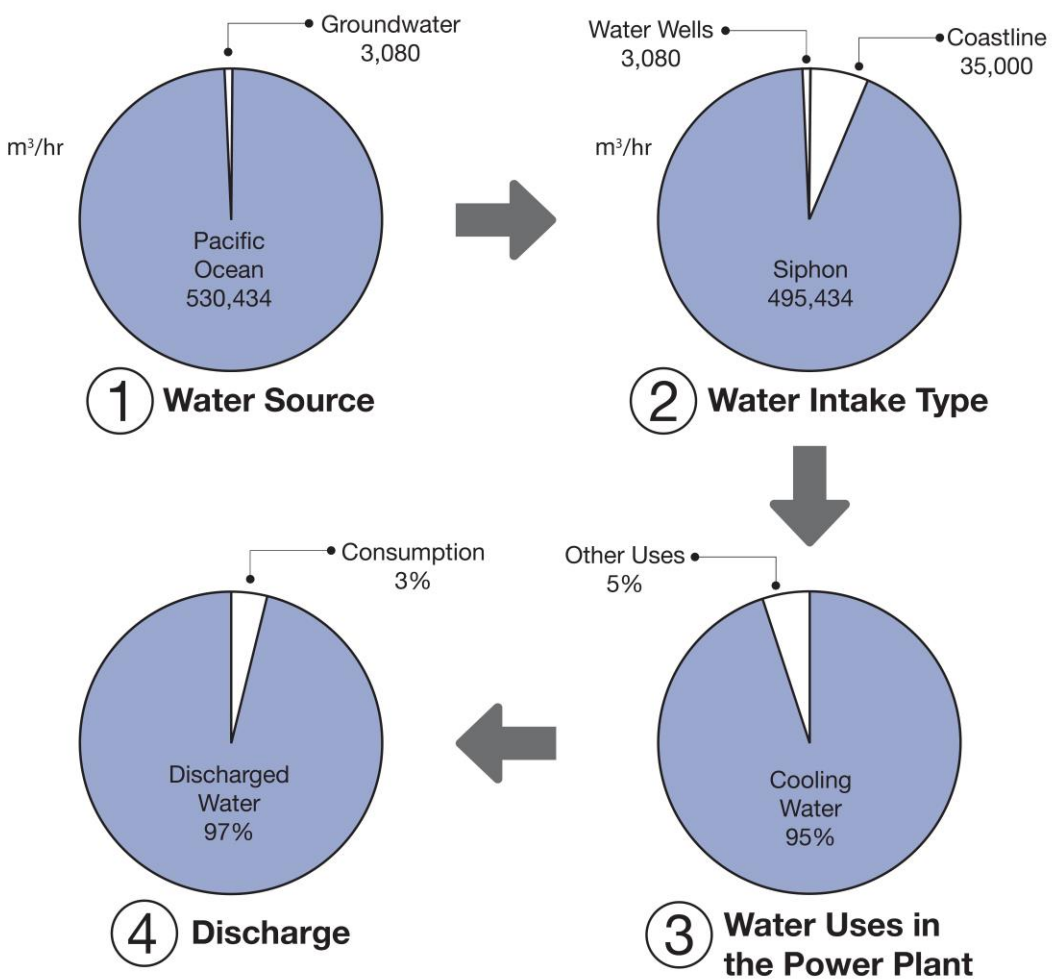
Scalability

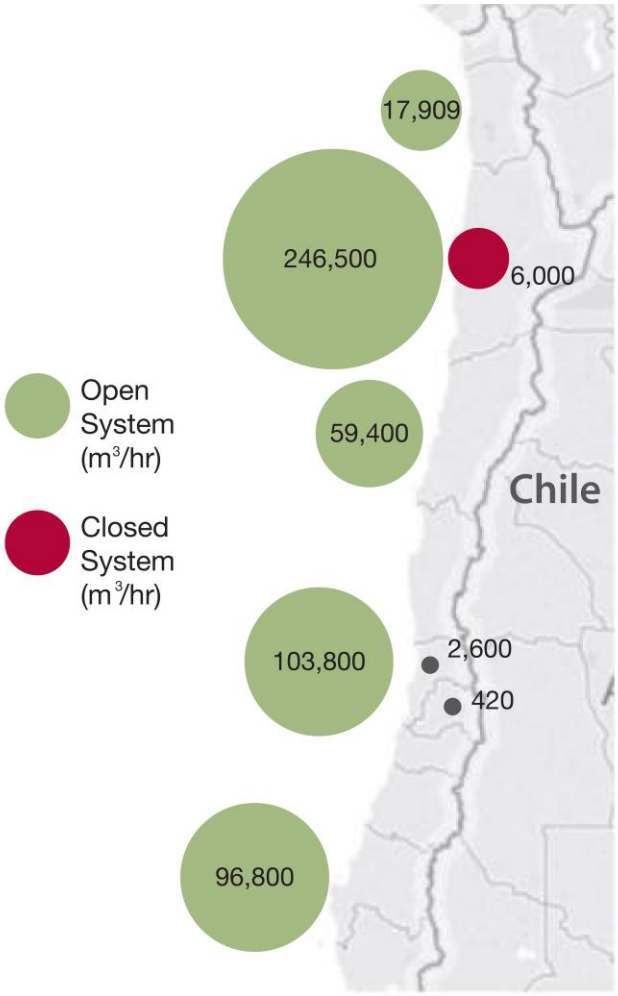
Resilience

Environmental Impact (Noise)

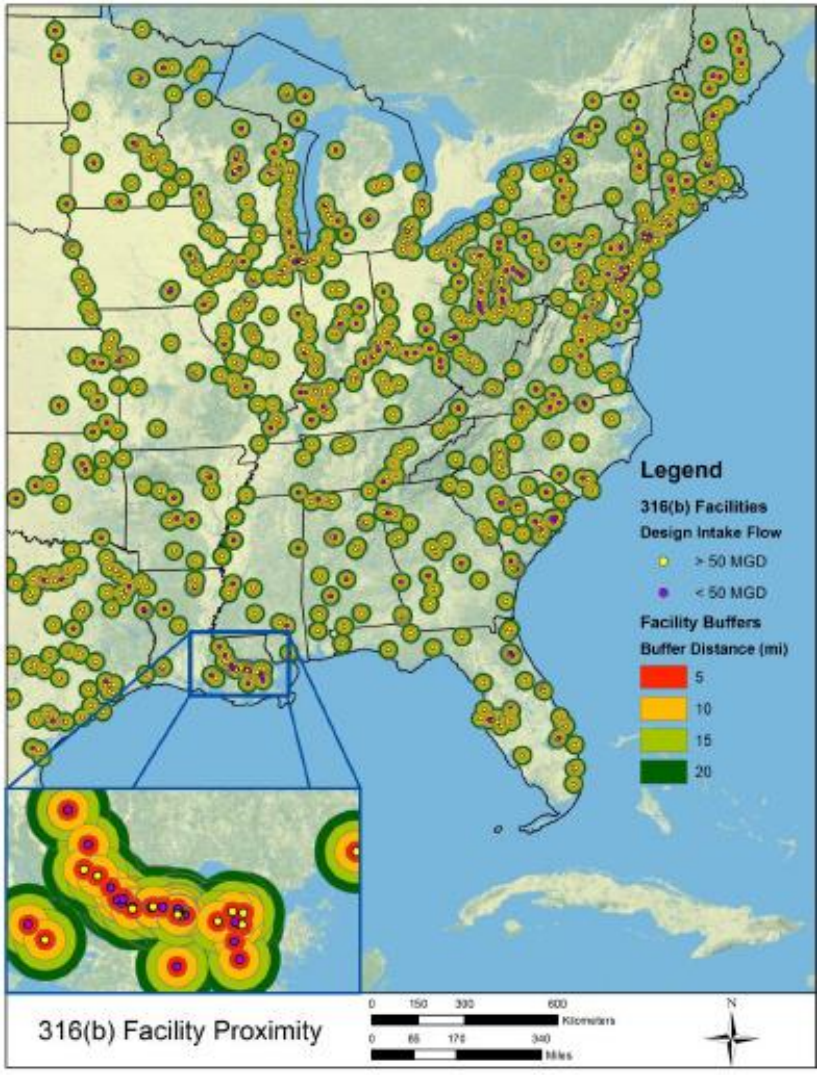
Rubustness

Water use in Thermoelectric Facilities in Chile





Differences in Geographical Context: The US Case



Facility Proximity Analysis:

30% the facilities have at least one facility located at least 5 miles from another facility

62% the facilities have at least one facility located at least 15 miles from another facility [Source: US EPA 2014]

Water Body	Number of Facilities	Percentage
River	349	52 %
Lake	134	20 %
Great Lakes	48	7 %
Estuary	117	17 %
Ocean	22	3 %

Exclusion and collection technologies installed in water intake systems in Chile as of 2016.

Exclusion and collection technologies installed in water intake systems in Chile as of 2016.

Installed Exclusion and Collecting Technologies	Quantity
Travelling Screens	24
Trash Racks	27
Wedge-Wire Screens	2
Fish Nets	14
Fish Nets + Air Bubble Barriers	2
Rack on Siphon Intake	4
Fish Handling and/or Return Systems	3

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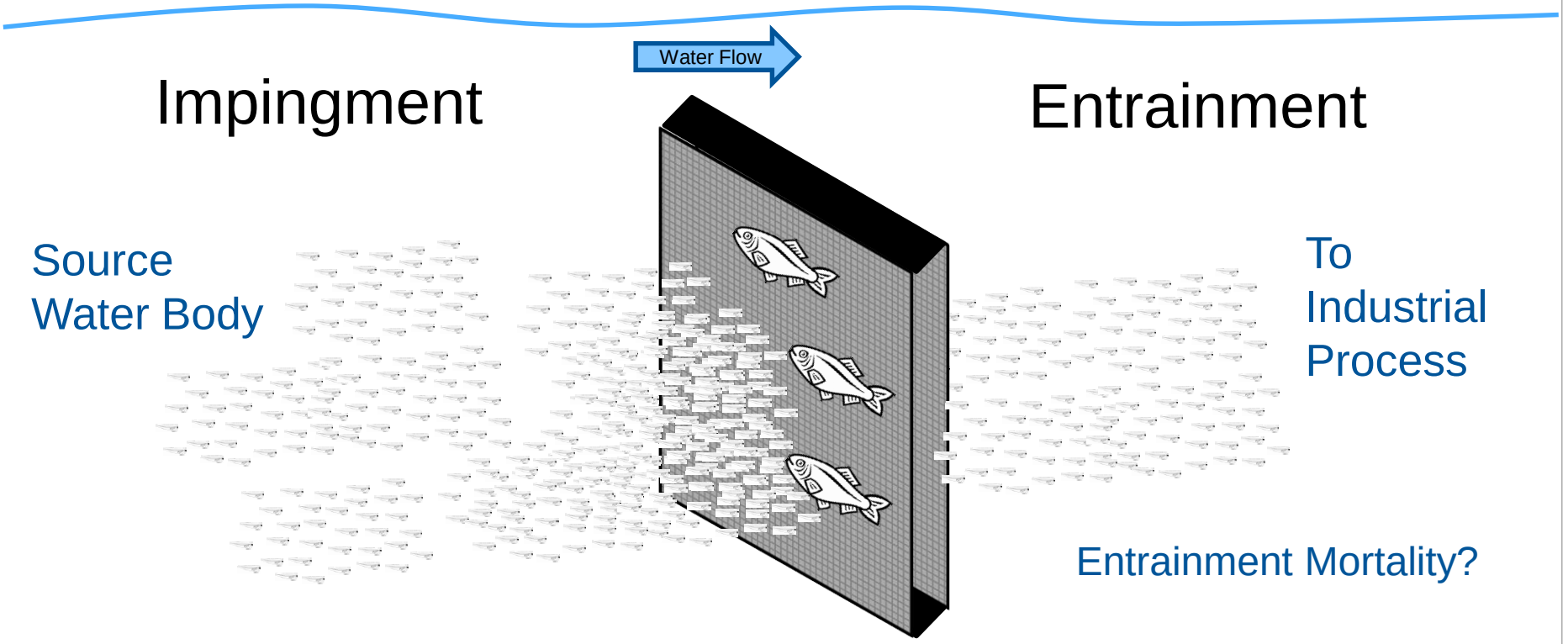
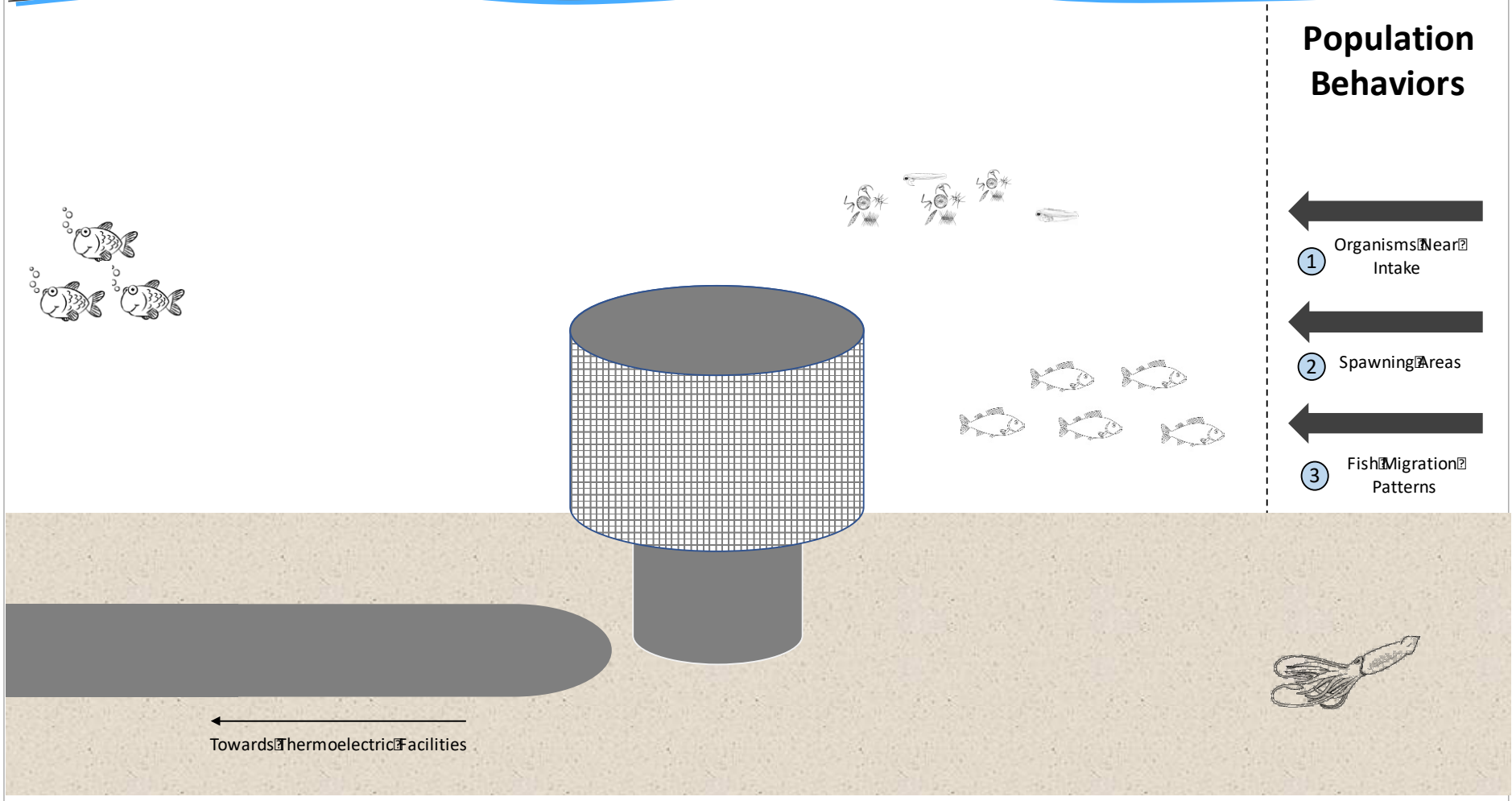
Key Impacts of Withdrawing Water



Key Metrics:

- Number of Individual (fish, Larvae, Eggs) Lost per Year
- Number of Adult Equivalent Losses (1-year-age) per Year
- Other metrics

Facility Design Parameters, Organism's Biological Traits and Population Behaviors which determine effects of impingement and entrainment



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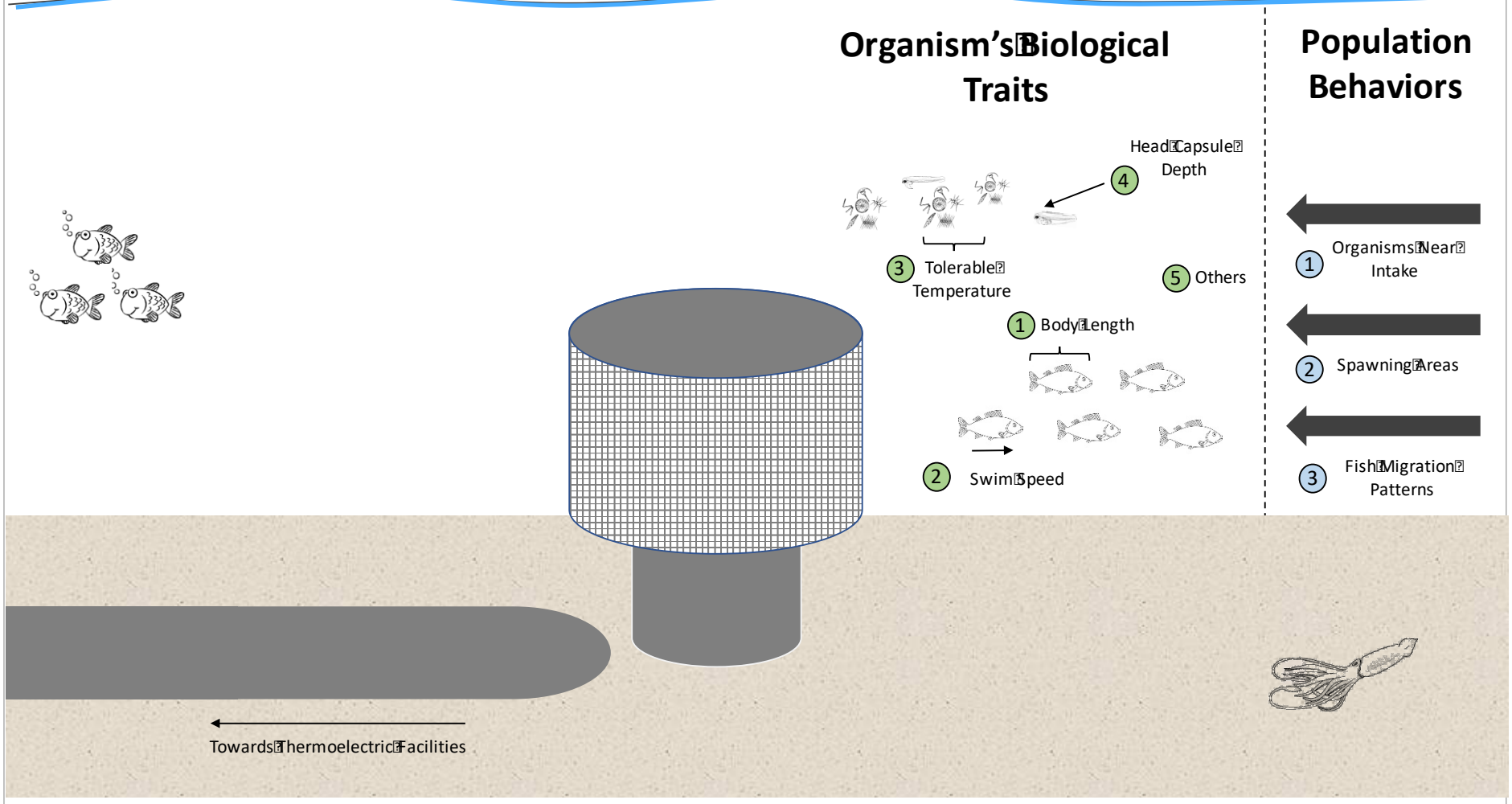

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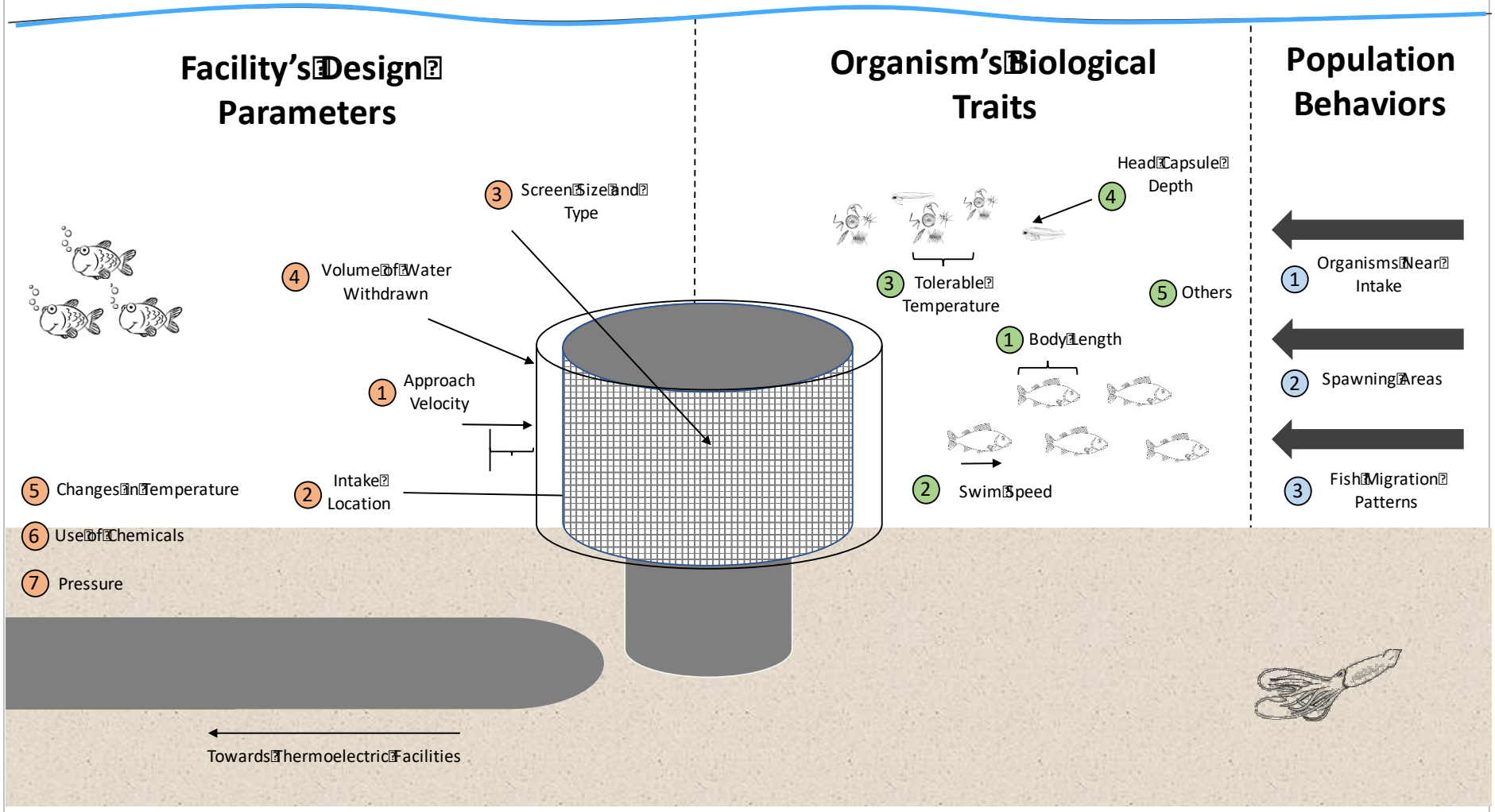
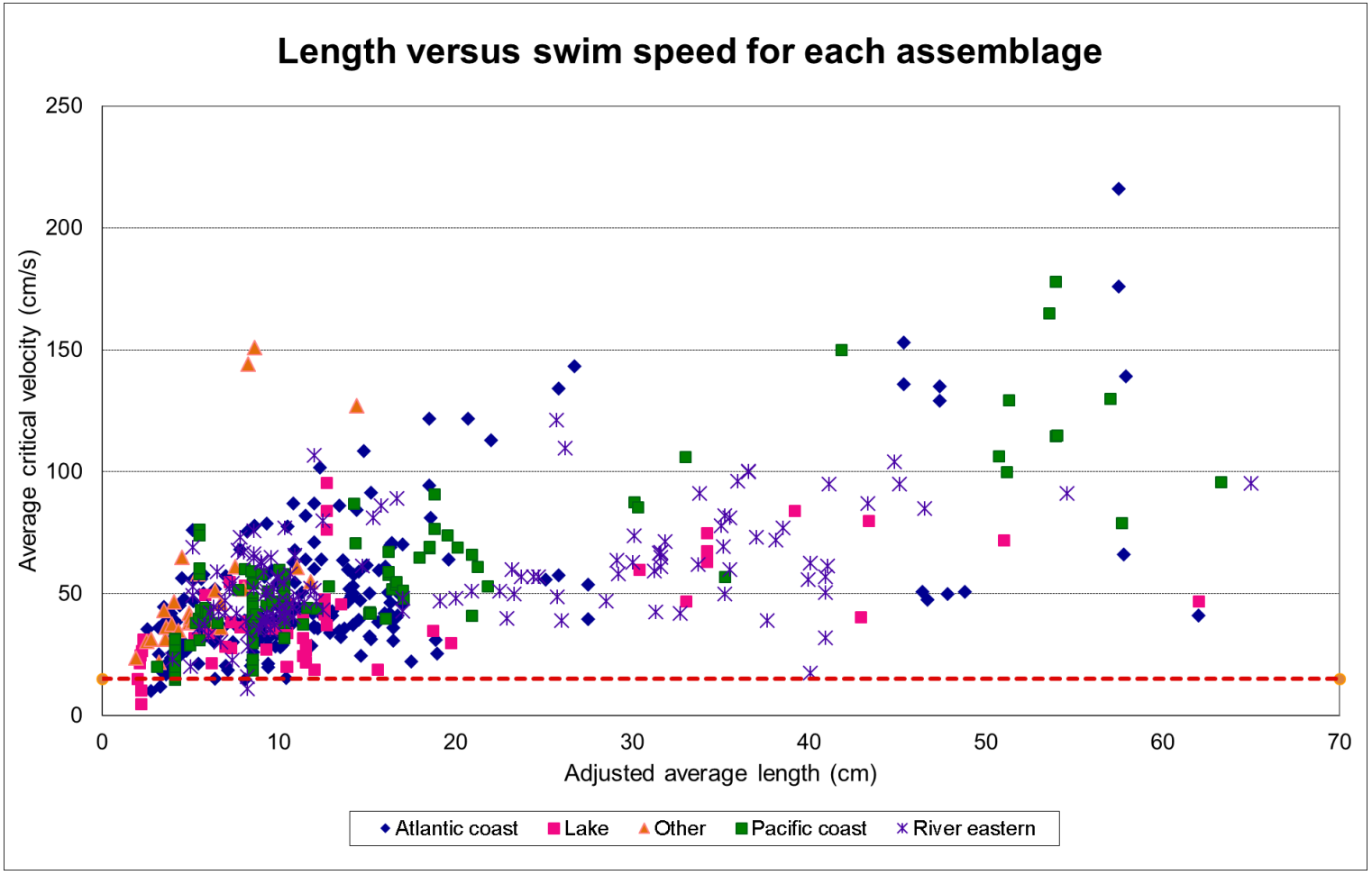
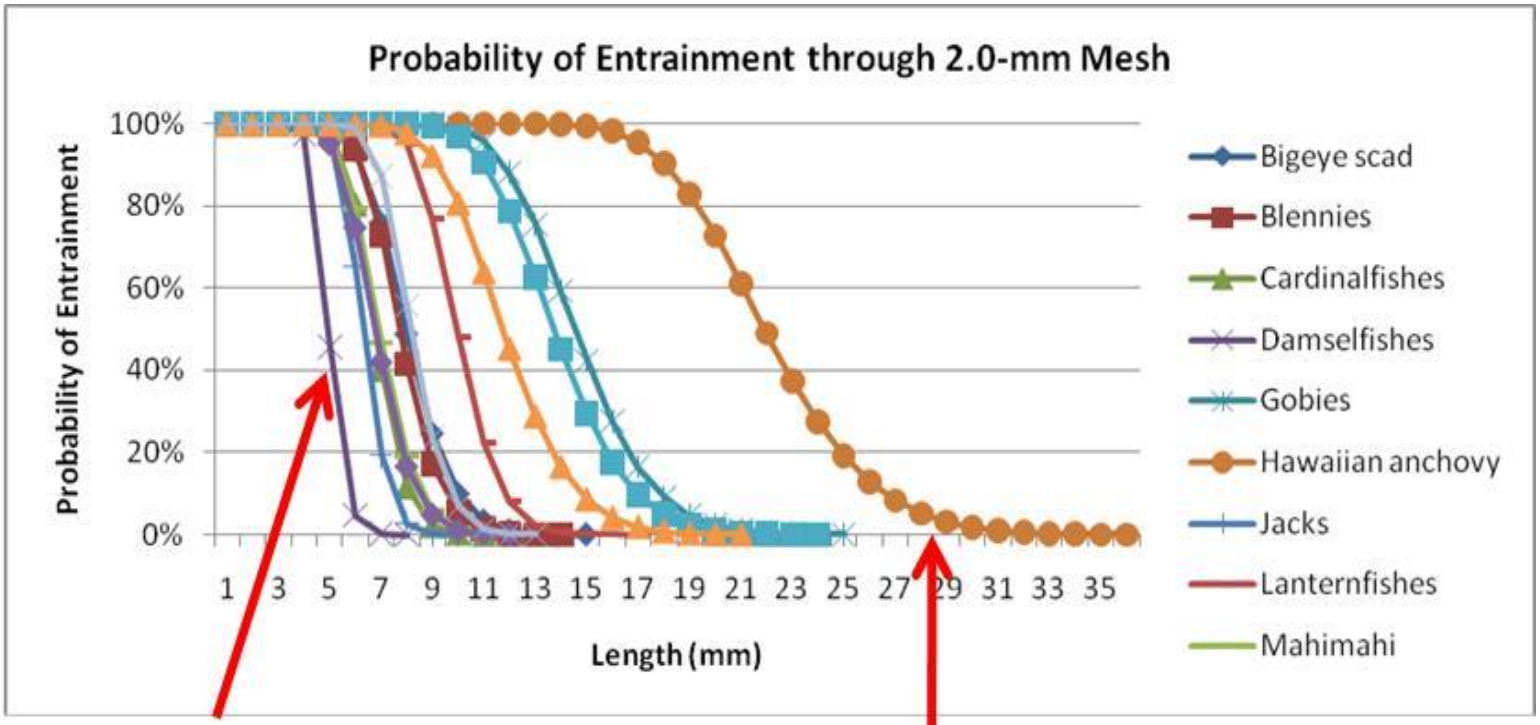


The Fish's Swimming Ability and its Susceptibility to Entrainment

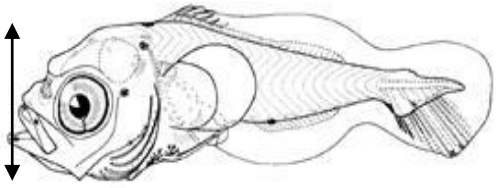


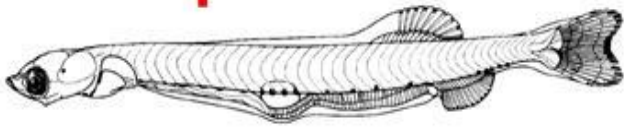
[Source: Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b). EPRI, Palo Alto CA, 2000. 1000731.]

The Larvae's Morphological Variations and its Susceptibility to Entrainment



Head Capsule Depth





[Source: HDR Inc. 2016 & T. Hogan 2015]

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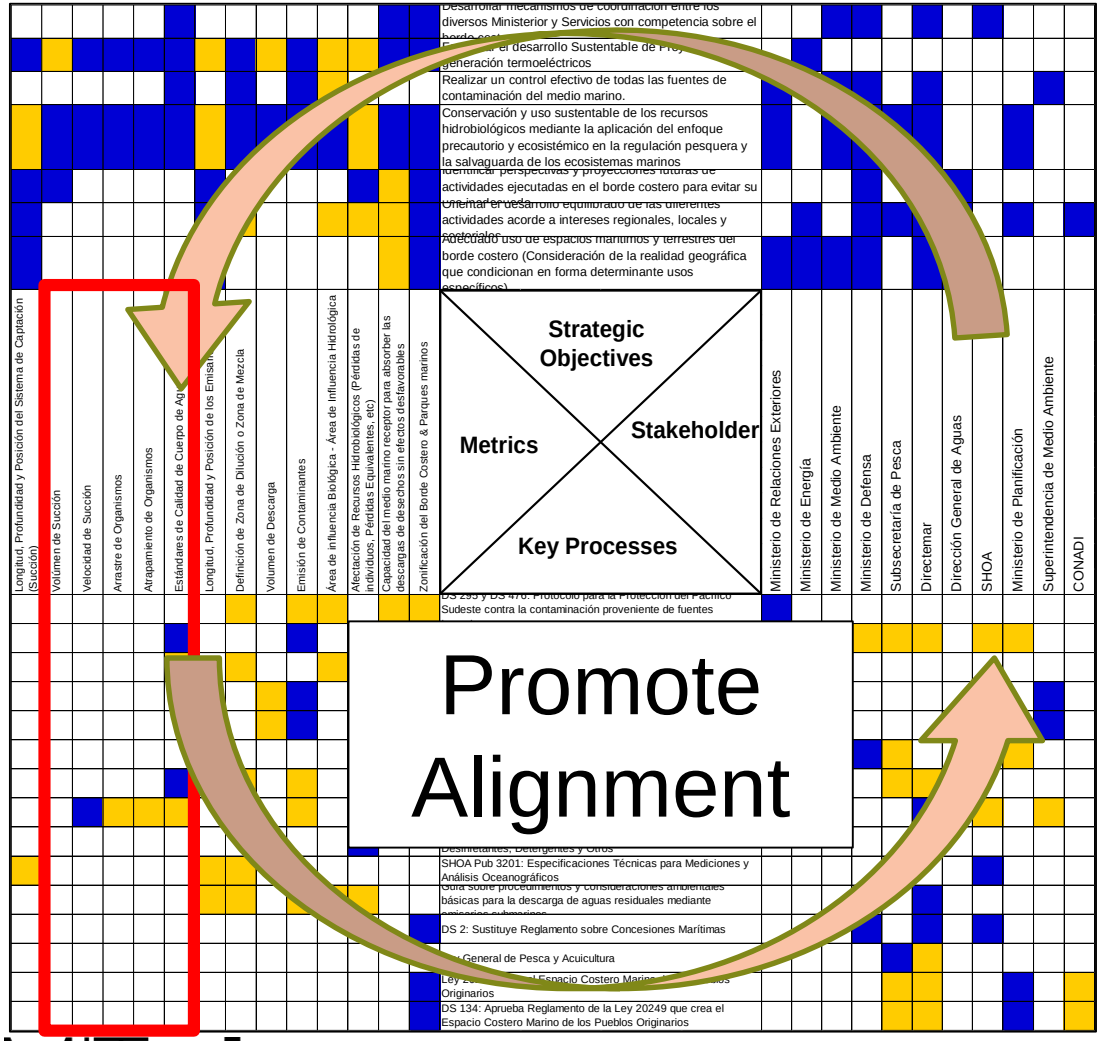
Holistic Analysis of Regional Context - Assessed Systemic Needs and Found Opportunities to Promote Institutional Alignment



+11 Stakeholders

Wide range of objectives

Complex Regulatory Context (Laws, ByLaws, Procedures, Guides)

Complex requirements (metrics & processes)

- Ambiguity
- Lack of metrics
- Procedures
- Structure

Lack of requirements for regulating environmental impact of withdrawing water

Policy Benchmark: Best Practices in some OECD Countries

EPA US Environmental Protection Agency	ENVIRONMENT European Commission
Clean Water Act Section 316(b)	Water Framework Directive Integrated Pollution Prevention and Control Directive Marine Strategy Framework Directive
To **reduce impingement and entrainment** of fish and other aquatic organisms at cooling water intake structures used by certain existing power generation and manufacturing facilities for the withdrawal of cooling water from waters of the United States.	To establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which: a)… b)… c)… d)…

Policy Benchmark: Best Practices in some OECD Countries

In US: Each State can define particular procedures and requirements to apply rule 316(b), for example, regarding entrainment impact assessment and cost-benefit analysis of water intake alternatives.

In EU: Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive

EPA US Environmental Protection Agency	ENVIRONMENT European Commission
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Policy Benchmark: Best Practices in some OECD Countries

Specific requirements defined in terms of metrics that the operator of the power plant can directly manage.

To reduce impingment it prescribes 7 alternatives.

To reduce entrainment it requires that the Director must establish the BTA entrainment requirement for a facility on a site-specific basis.

EPA US Environmental Protection Agency	ENVIRONMENT European Commission
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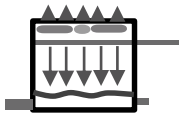
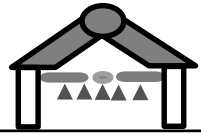
Total Investment Cost Analysis for Cooling Systems

Cooling System for 260 MW Coal Plant		Once through Cooling 	Cooling Tower 	Cooling Pond 	Air Cooled Condenser 
Cost of Water Intake or Withdrawal System	Overhead Siphon	k US$ 160- 267 per meter	k US$ 160- 267 per meter	k US$ 160- 267 per meter	$0
	Submarine System	k US$ 67 -133 per meter	k US$ 67 -133 per meter	k US$ 67 -133 per meter	$0
Installed Cooling Component Cost	Mejillones	N/A	M US$ 5,6 – 6,5	M US$ 7,2 - 8,7	M US$ 45,6 - 50,9
	Quintero	N/A	M US$ 5,7 – 6,7	M US$ 7,9 - 9,4	M US$ 45,6 - 50,9
	Quillota	N/A	M US$ 5,7 – 6,7	M US$ 8,7- 10,2	M US$ 58,3 - 62.2
	Coronel	N/A	M US$ 5,7 – 6,7	M US$ 6,3 - 7,8	M US$ 46,1 -51,4
Condenser Cost		18– 44 US$/m3 hr (*)	18– 44 US$/m3 hr (*)	18– 44 US$/m3 hr (*)	
Cost of pumping system		Cost of pumping system			$0
Other Significant Costs to Consider		Intake Protection System cost Water Use Permit cost, Development & Engineering Costs, Piping costs	Intake Protection System cost Water Use Permit cost, Development & Engineering Costs, Piping costs	Intake Protection System cost Water Use Permit cost, Development & Engineering Costs, Land Costs	Land Costs, Development & Engineering Costs

Once Through Cooling vs. Closed Loop Cooling System

	Mejillones	Quintero	Coronel
Wetbulb Temperature (1%)	20 °C	18,5 °C	19,5 °C
Dry Bulb Temperature (1% Wet Bulb)	24 °C	24 °C	25 °C
Relative Humidity (1% Wet Bulb)	70%	59%	60%
Water Avaliable	Ocean	Ocean	Ocean
Water Quality	34,4 g/l	34,4 g/l	34,4 g/l
Average Water Temperature	17 °C	15 °C	14 °C
Power Loss for 10 °C Temperature Increase	5.74%	6.15%	7.87
Power loss for 30 °C Discharge Temperature	7.05%	7.87%	9.51%

The conversion of a once through cooling system to a closed loop cooling system for an ocean location power plant imposes significant costs in terms of performance, operation, and, ultimately, cost of electricity.

Recommended a Once-Through Cooling System with a Properly Designed Intake which Minimizes Adverse Environmental Impacts

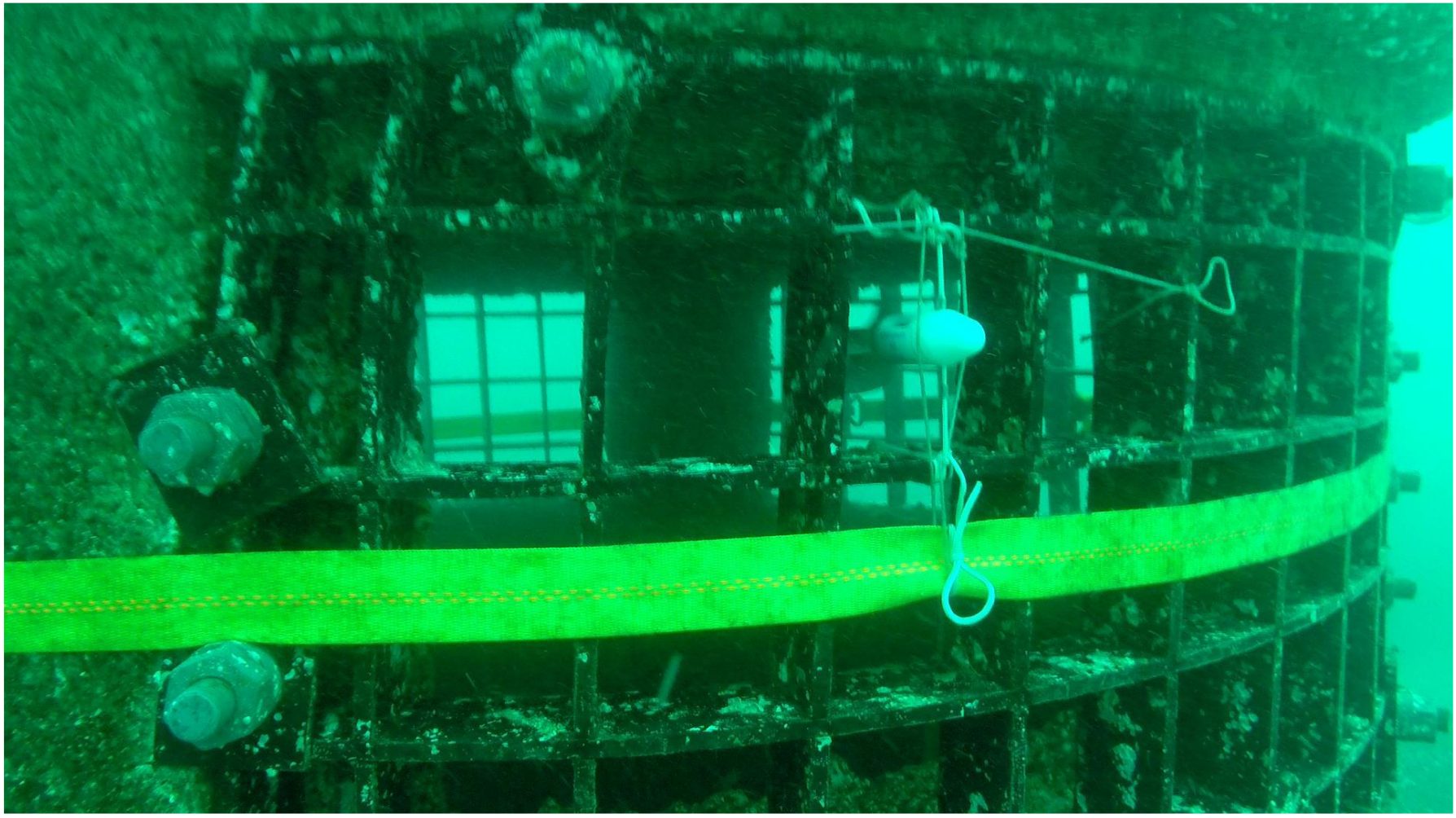
A Once-Through Cooling System located in the Chilean Coast with a Properly Designed Intake and which Minimizes Adverse Environmental Impacts:

1. Allows for a more energy efficient thermoelectric facility which reduces emissions

2. Can reduce entrainment to a level commensurate with the flow reduction associated with closed-cycle cooling (i.e., 90%)

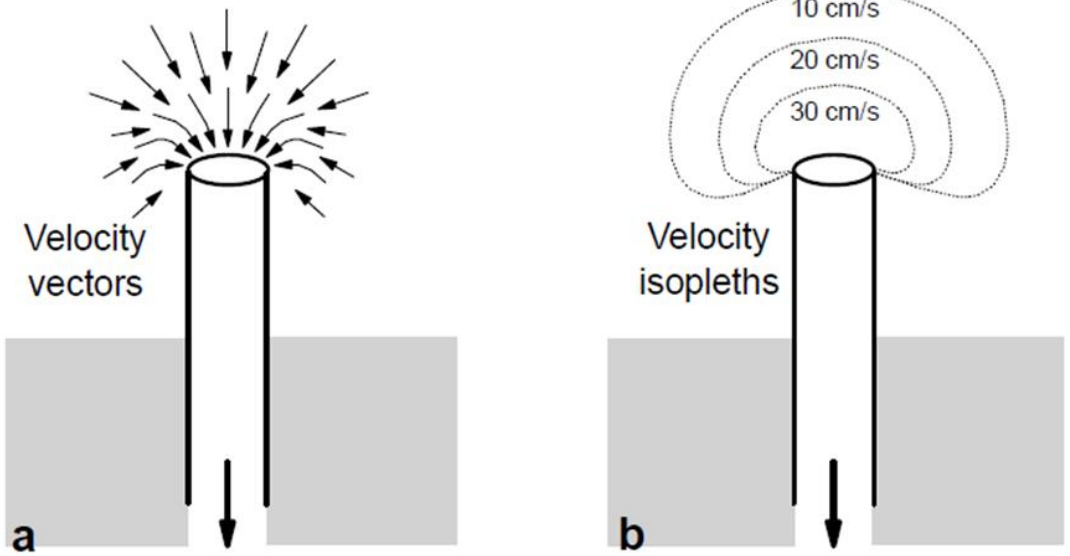
3. Most cost effective solution in Chile

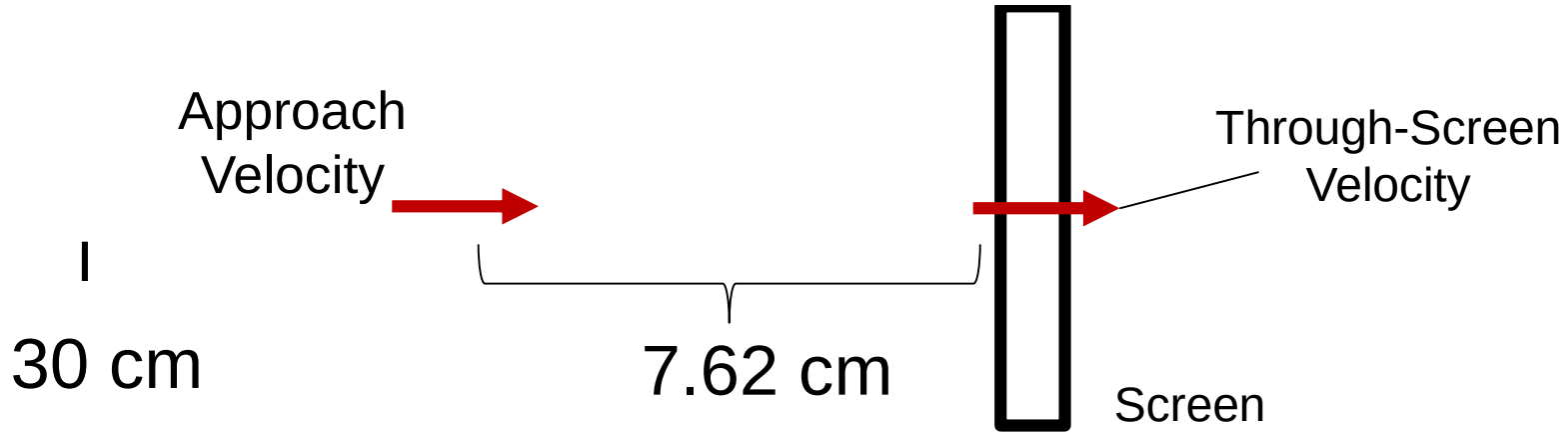
Challenges Measuring Through Screen Velocity



[Source: Costasur]

Approach Velocity Adopted Instead of Through-Screen Velocity





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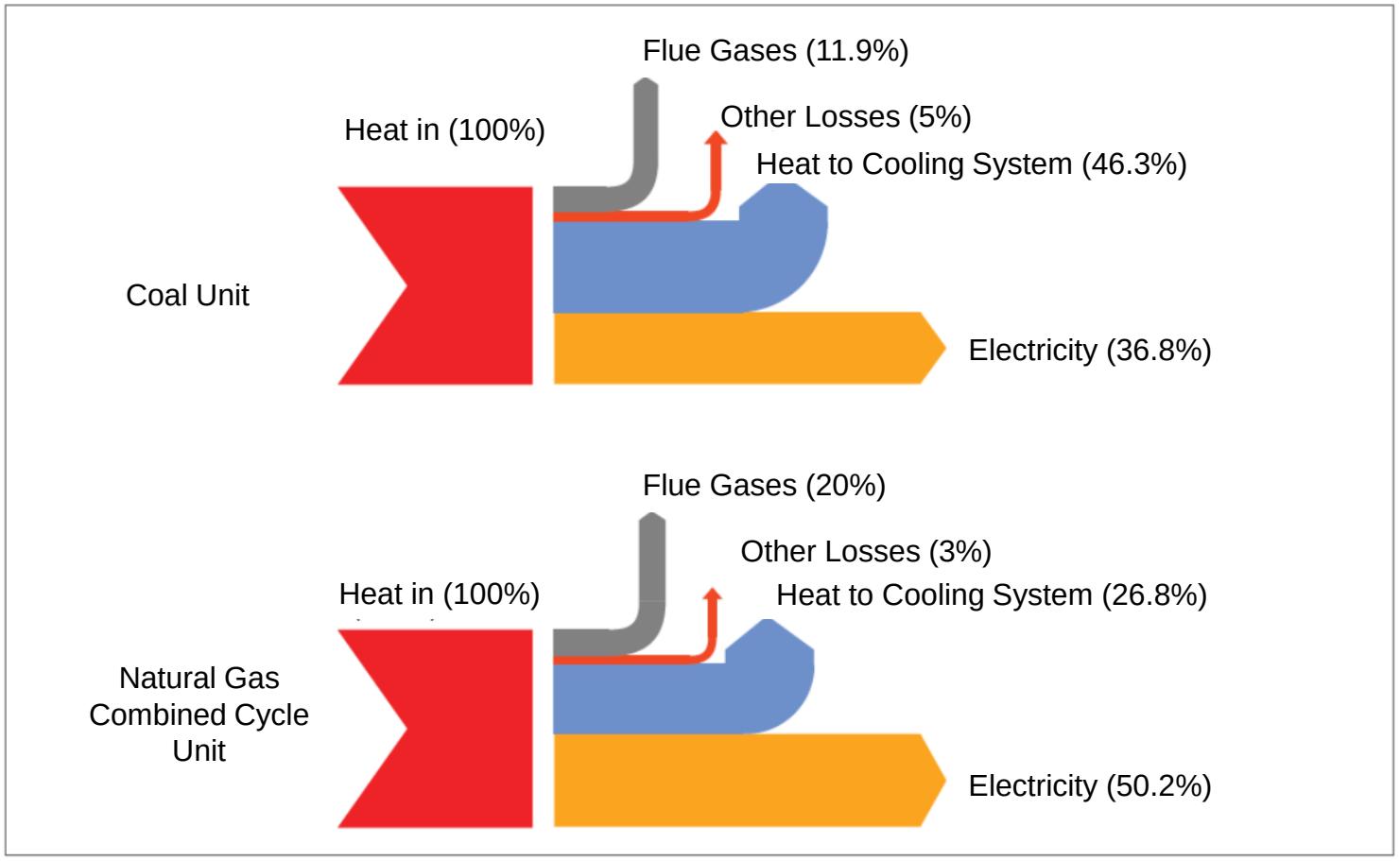
1. More Efficient Thermoelectric Facility



[Source: Anna Delgado, 2012]

2. Adequate Selection of Water Intake Location

- Guidelines to conduct a study which can show if an intake withdrawal location is adequate – Annex 12 of Study for Ministry of Energy

- It is important to consider the following criteria for the intake location:
  - If the intake location is near a spawning area
  - The number of individuals near the intake
  - If intake location intersects with a migration route
  - The intake location significantly affects the life cycle of a valuable species

- The thermocline is not a good indicator of how the intake will impact the water body.

- The intake should be located at a depth of between 5 meters and 15 meters divers can maintain and repair if needed.

3. Selection of Cooling System

- A preferred option for the Chilean Coast is the Once-Through Cooling System:
  - which has a properly designed, operated and maintained water intake and discharge system;
  - and has a water intake system which minimizes adverse environmental impacts

- A closed loop cooling system is the preferred option in coastal zones where there the altitude at which the facility is located makes it inefficient to pump the water required by a once through cooling system

- A dry cooling system – in areas where there is water scarcity.

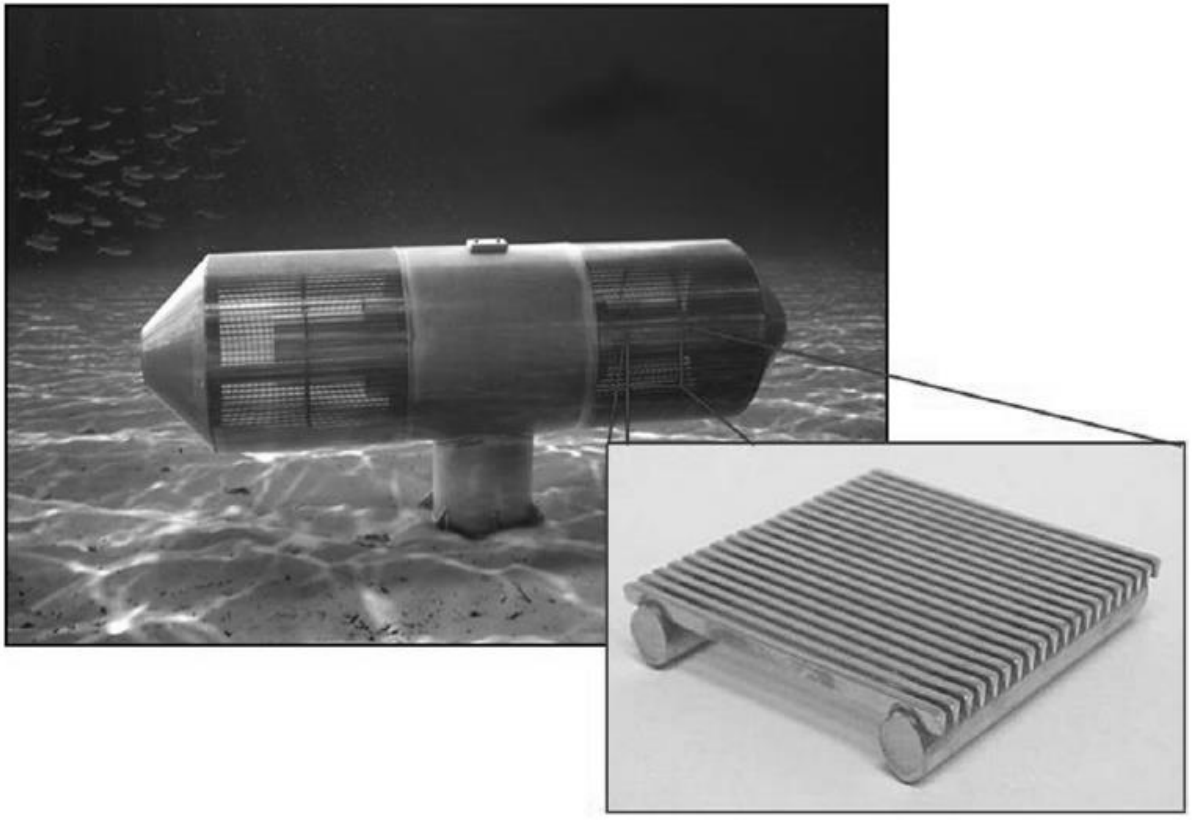
4. Reduce Intake Velocity

- To operate a water intake system with a maximum water intake velocity of 15cm/sec. The design water intake velocity should be estimated a distance which is less than 8 cm away from the intake screen.

- Operate a water intake system with a maximum average velocity of 15 cm/sec.

5. Properly Designed Intake which Minimizes Adverse Environmental Impacts

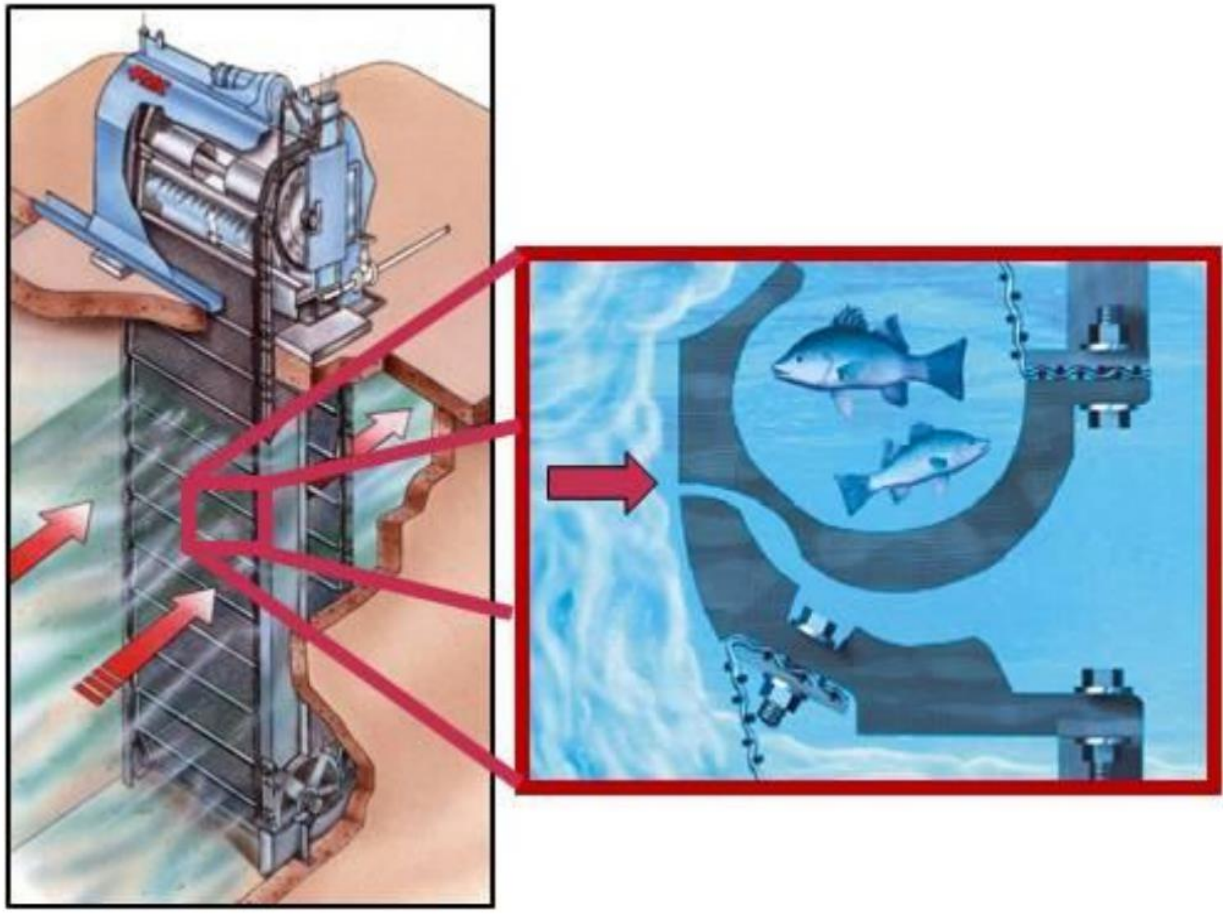
Wedgewire Screens



[Source: Johnson Screens]

5. Properly Designed Intake which Minimizes Adverse Environmental Impacts

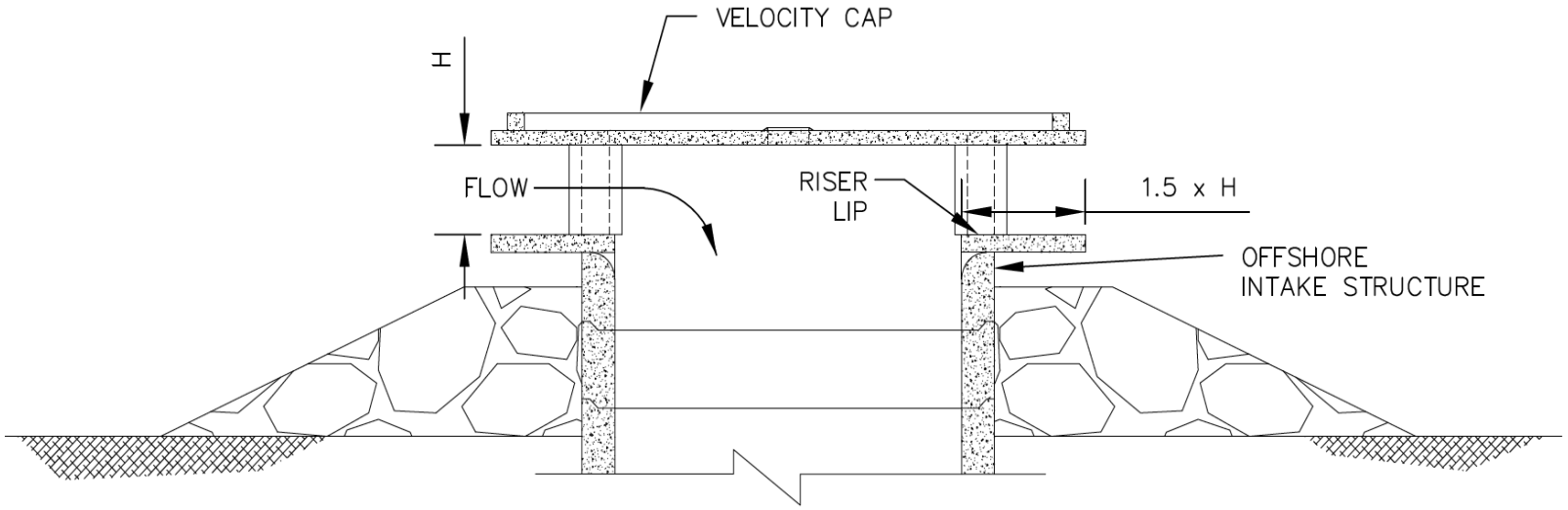
Travelling Screens with Fish Return System



[Source: Siemens]

5. Properly Designed Intake which Minimizes Adverse Environmental Impacts

Velocity Cap



[Source: Alden Lab]

5. Properly Designed Intake which Minimizes Adverse Environmental Impacts

Other Options

[Source: Geiger]

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Chilean Guide with Methods to Assess Intake Impacts – Cost-Benefit Analysis

Endpoint	Category of assessment method	Method and measure	Conceptual complexity	Information requirements	Can quantify density-dependence	Can quantify multiple stresses (e.g., fishing)	Difficulty of measurement	Effort & expertise required	Response time	Uncertainty	Relevance for population	Understandability & acceptance by non-experts
Individual	Absolute losses	Number killed	Low → High	Low → High	No	No	Low → High	Low → High	Short → Long	Low → High	Low → High	High → Low
		Equivalent adult losses										
Cohort	Fractional losses	Habitat ratio										
		Conditional mortality rate										
Population	Population projections	Age/stage-based model			Yes	Yes						
		Individual-based model										

[Source: EPRI 2002]

Acknowledgments

Carl Bozzuto, **Independent Consultant**

Guide:
http://www.minenergia.cl/archivos_bajar/ucom/publicaciones/Guia_Buenas_Practicas_Termoelectrica.pdf

Questions?

system design & management

Best Practices for Water Use at Thermoelectric Facilities

MITsdm

- Donny Holaschutz, SDM'10 & inodú cofounder
- Jorge Moreno, SDM'11 & inodú cofounder
- Carolina Gómez, Sustainable Development Division
  Ministry of Energy, Chile

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